State of Wisconsin/Department of Transportation

RESEARCH PROGRESS REPORT FOR THE QUARTER ENDING: December 31, 2008

Program: SPR-0010(36) FFY99	**Part: II Research and Development**
Project Title: Effective Depth of Soil Compaction in Relation to Applied Compactive Energy	**Project ID:** 0092-08-11
Administrative Contact: Daniel Yeh	**Sponsor:** Wisconsin Department of Transportation
WisDOT Technical Contact: Bob Arndorfer	**Approved Starting Date:** 10/10/07
Approved by COR/Steering Committee: $54,914	**Original End Date:** 4/10/09
Project Investigator (agency & contact): Dante Fratta & Haifang Wen - University of Wisconsin-Madison	**Current End Date:** 4/10/09 **Number of Extensions:** 0

Percent Complete: 70%

Request a No Cost Time Extension (Please Select One): ☐ **YES** ☒ **NO**

Reason for No Cost Time Extension: None

Project Description:

The determination of the appropriate lift thicknesses used in embankment construction operations has important economic and engineering implications in the design and construction of roads, levees and dams. For example, small lift thicknesses may cause excessive construction costs while large lift thicknesses may reduce the compaction effectiveness and compromise the integrity of the embankment. This research proposal will use experimental results and numerical analyses to evaluate the effective depth of compaction. These results and analyses will provide engineering understanding of the problem and justify recommendations about maximum lift thickness to be used in WisDOT embankment construction projects.

This proposed research program collects data and develops analyses needed to determine optimum lift thickness for WisDOT embankment construction projects. The results will help to establish relationships between the applied compaction energy and the level of compaction achieved at increasing depths for a number of different soils and moisture contents. The data, analyses, and correlations will help WisDOT officials in proposing possible revisions to current constructions specifications including the need to change the established 8-in lift thickness in the construction of compacted embankments. The successful completion of this research will also help WisDOT officials in improving construction operations by creating more stable and economical subgrade structures.

Progress This Quarter:

During this quarter, the research team interpreted field data and evaluated the changes of soil characteristics due to field soil compaction. The research team has begun numerical modeling and analysis to evaluate the compactive energy propagation in embankment construction operations.

The research team also presented preliminary results to the Wisconsin Earth Moving Association (WEMA) meeting on December 11, 2007 at Wisconsin Dells, WI. A copy of the presentation is attached to this report.

Field Data Interpretation:

The test sections were compacted using the three types of compaction equipment: rubber-tired roller (wheel dozer), smooth-drum vibratory roller, sheepsfoot roller, and scraper. To evaluate the characteristics of soil properties after compaction, soil stiffness gauge (SSG), time domain reflectometry (TDR), nuclear density gauge, and dynamic cone penetrometer (DCP) tests were conducted. Figure 1 shows the different types of instrumentation and test used in the characterization of the compaction quality results.

To investigate the compactive energy propagation (pressure, stiffness changes, and inclination) in the soil, the pressure plate and MEMS (miniature electro-mechanical systems) accelerometers were installed in the subbase soil (Figure 2).

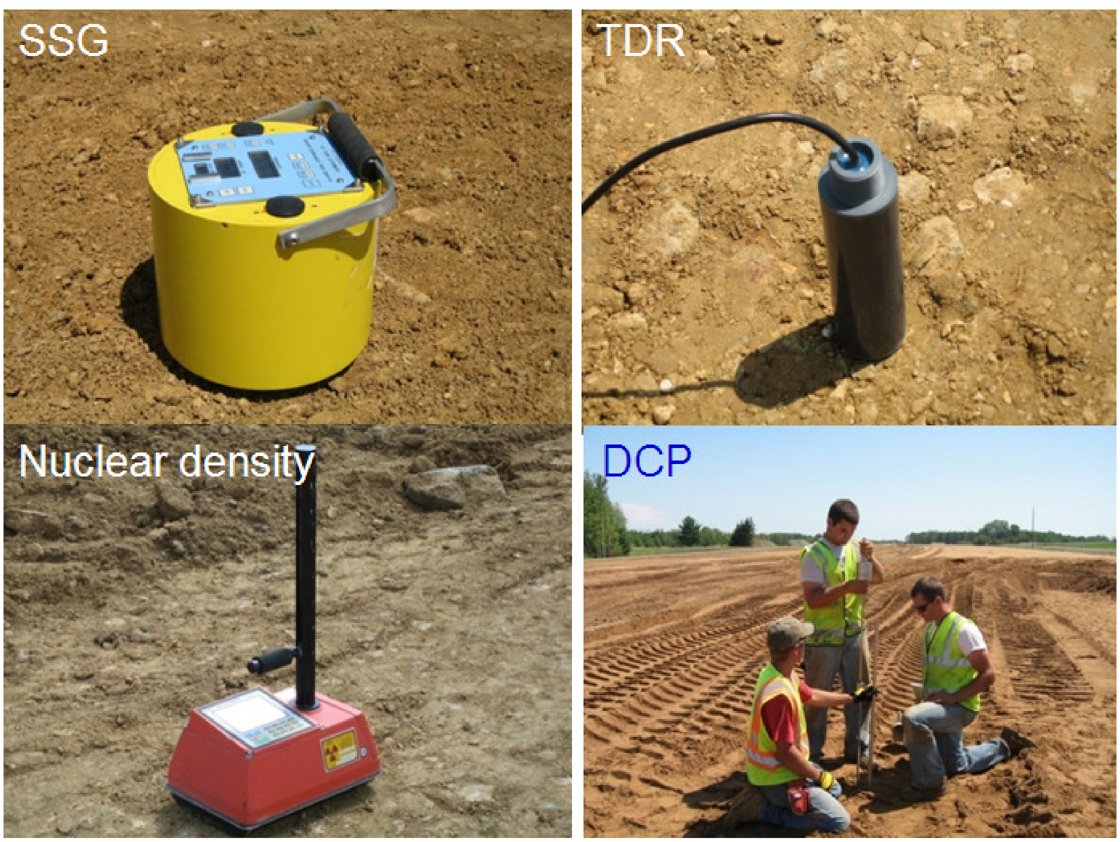

Figure 1. Various types of testing methods for the evaluation of soil characteristics: Soil Stiffness Gauge (SSG), Time Domain Reflectometry (TDR), Nuclear Density Gauge, and Dynamic Cone Penetrometer (DCP)

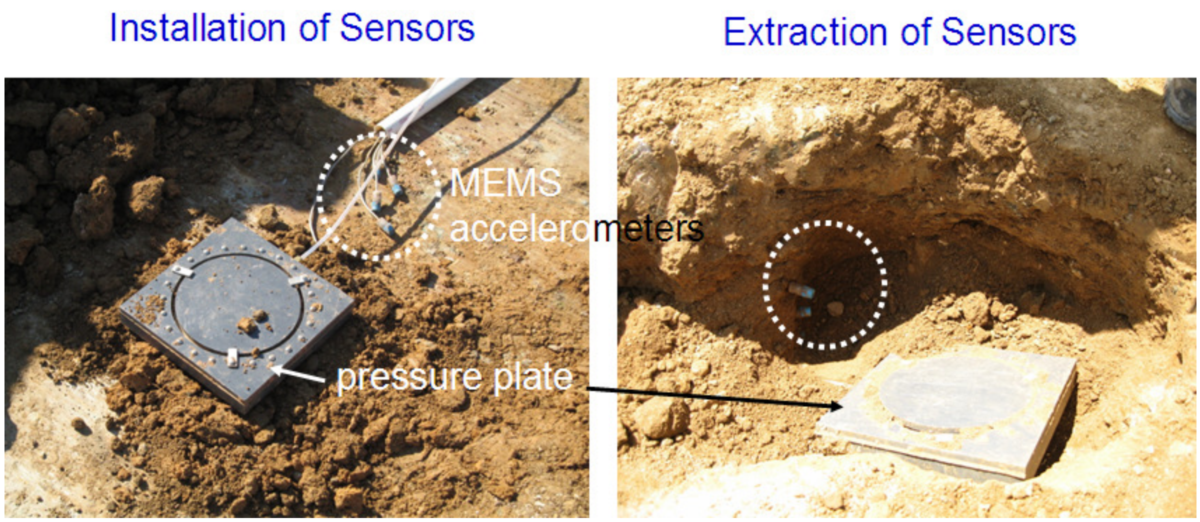

Figure 2. Installation of pressure plates and MEMS accelerometers for monitoring energy of compaction.

Examples of collected data include DCP penetration rate profiles for different lift thicknesses and compaction equipment (Figure 3), measure pressure at the bottom of the lift for different lift thicknesses and the compaction equipment (Figure 4), measured particle acceleration profiles for increasing number of passes (Figure 5), and particle rotation profiles versus different type of soils and number of passes (Figure 6). The data will be used to interpret the interaction of the compactor with different equipment, soil types, and lift thickness.

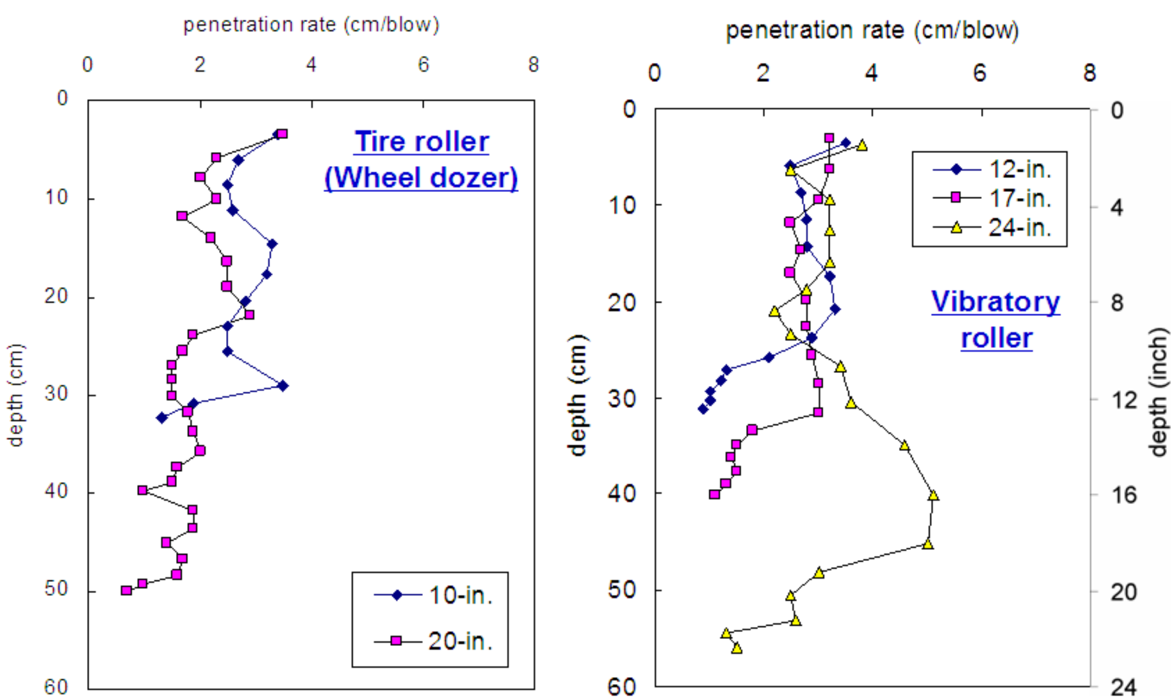

Figure 3. DCP index profile in depth.

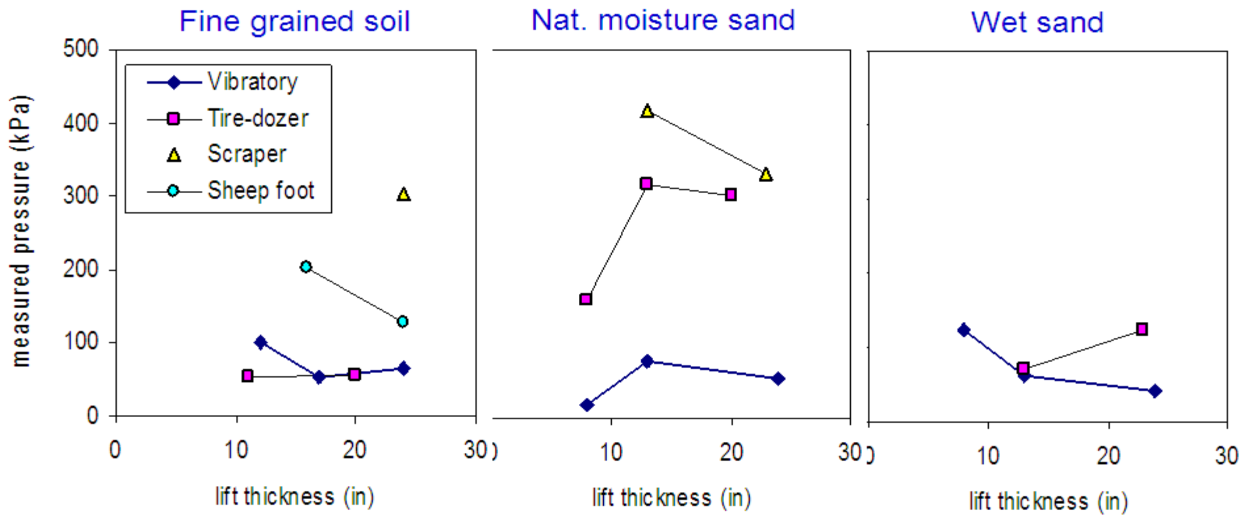

Figure 4. Maximum pressure of the pressure plate by different types of compactors.

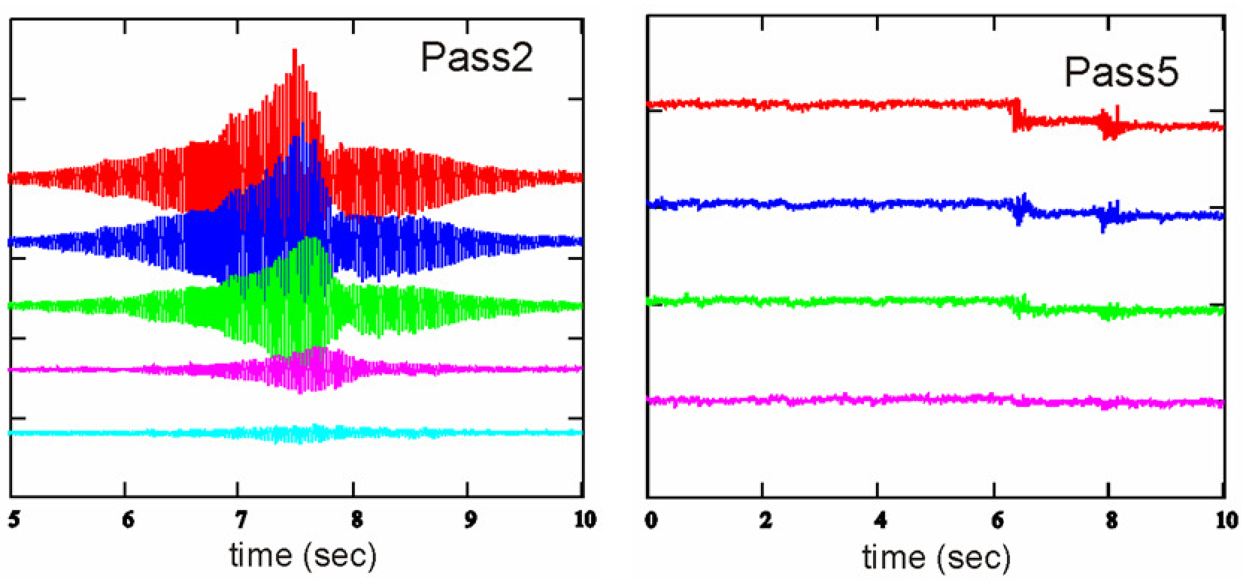

Figure 5. The acceleration responses by different types of compactors.

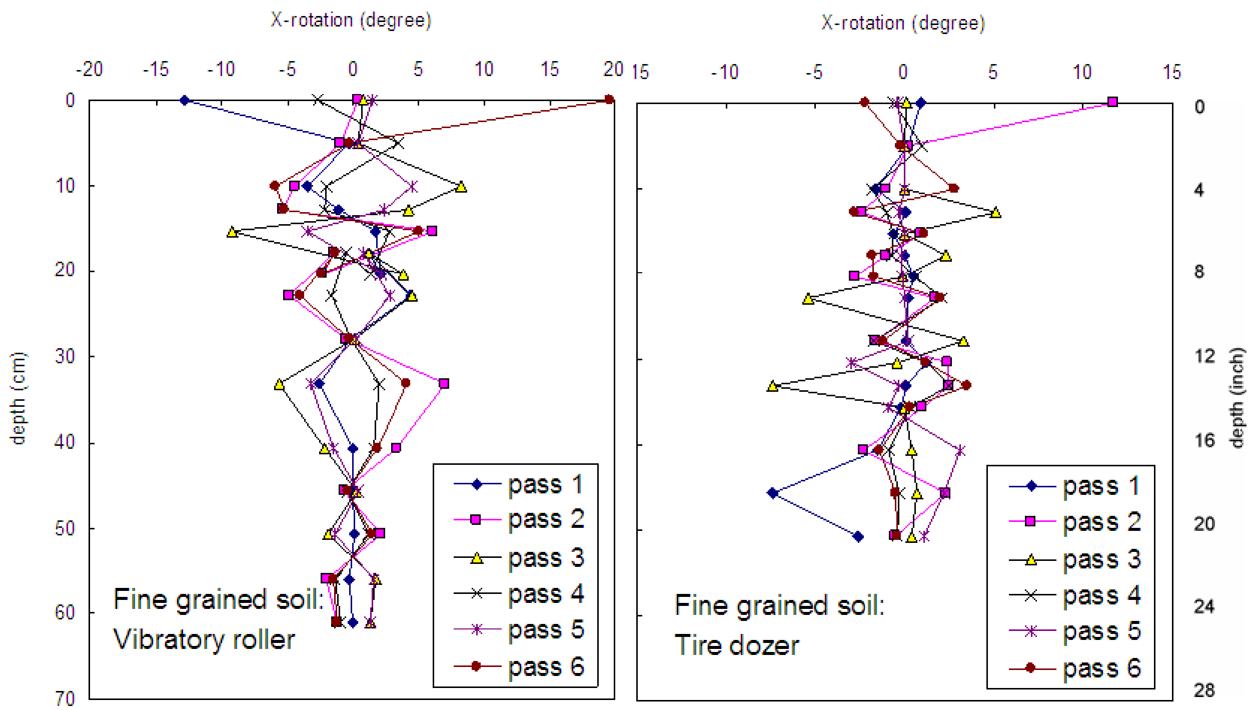

Figure 6. The rotation of MEMS accelerometers in the soil by passing soil compactors.

Work Next Quarter:

During the sixth quarter, the research team will establish correlations between the field measurements and the theoretical/numerical predictive models to estimate the compaction energy and the efficiency at depth for different soils and lift thicknesses.

Circumstances Affecting Progress/Budget:

None

Gantt Chart:

Phase Number	1.5 Years (18 months)					
	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Quarter 5	Quarter 6
Phase I						
Phase II						
Phase III						
Phase IV						
Phase V						